Integrating Statistics with Geometry and Measurement

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Overview

The President of ASA, Utts, recently encouraged mathematics teacher educators to join efforts in creating a statistically literate society by implementing recommendations found in Statistical Education of Teachers (SET; Franklin et al., 2015). Evidence of this call is exemplified through modifying course materials to integrate statistics concepts with geometry and measurement in a combined content and pedagogy course for future middle grades teachers.

Background

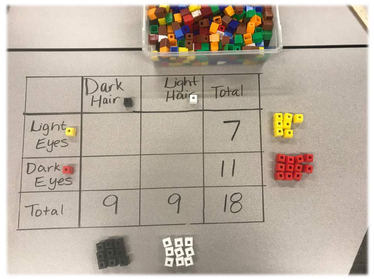
Statistics and mathematics are "allied disciplines" (Arcavi, 2003) with interconnected knowledge and researchers encourage mathematics and statistics educators to work more closely (Langrall, Makar, Nilsson & Shaughnessy, 2017).

- Over 20% of the mathematics curriculum in K-12 (mostly in middle and secondary grades) is now devoted to data analysis and statistics (Usiskin, 2015)
- "Measurement and geometry skills are intertwined in statistical problem solving" (Kader, Jacobe, Wilson & Peck, 2013)
- US students show weakness with geometry skills, higher cognitive demands, modeling real-world situations and use of the number π (PISA, 2002).
- Future teachers should regularly engage in the statistical problem-solving process in their courses (SET; Franklin et al., 2015).
- A mosaic plot may be helpful with proportional reasoning needed inreasoning with contingency tables (Phannkuch & Budgett, 2017)

Setting

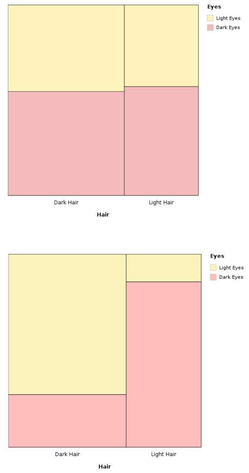
- Cohort of future middle grades teachers (N=18) in second semester of two year program:
- Geometry and measurement combined content and pedagogy course
  - Prior semester included Arithmetic content and pedagogy courses
  - Current semester included a content course in Algebra and Statistics
  - Following semester to include a pedagogy course in Algebra and Statistics.
- Active learning was a key component of the course.

Area and (In)dependence: Mosaic Plots



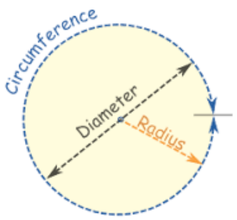
Future teachers placed a snap-cube representing their eye color and hair color, but not the combination.

- Question: If we know there is no association between hair color and eye color, what number of people would you expect to have light hair and light eyes.
- An interactive mosaic plot was used to explore this question and others about (in)dependence between categorical variables.
- Summative discussion focused on area represented in the mosaic plot and equivalent proportions signifying independence.



Circles, π, Distribution and Variation

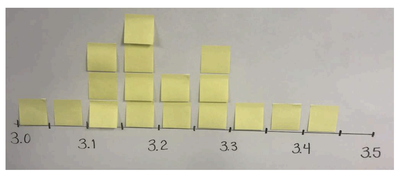
- Future teachers walked along the circumference, diameter and radius of a circle taped on the floor. They recorded their number of steps and calculated the ratio of circumference to diameter on the board.
- Discussion focused on circle attributes, conceptual meaning of π, measurement variation, distribution and measuring variation with absolute difference.



$$\frac{\text{Circumference}}{\text{Diameter}} = \pi = 3.14159\ldots$$

Diameter	Radius	Perimeter	Ratio (Circumference/ Diameter)	Absolute Difference
23	11	71	3.087	0.055
20	11	65.5	3.275	0.133
20	10	64	3.200	0.058
21	10	68	3.238	0.097
			:	:
19	9.75	59	3.105	0.036
20	10	64	3.200	0.058
20	11.5	66.5	3.325	0.183
		AVERAGE	3.209	0.090
		π (Pi)	***3.142***	

Future teachers computed an estimate of π and plotted their value to create a distribution.



Volume Measurement as a Statistical Question

- Future teachers were given boxes of different dimensions and challenged to measure the volume of the classroom in this non-standard measurement unit.
- They measured the boxes in standard units and computed the volume of the classroom in standard units.
- Discussion focused on measurement as an inherently statistical question that anticipates variability.

Observations

- Engaging in real data gathering and activities with FTs created engagement and rich discussion related to conceptual understanding of topics.
- "Proportional means independent" is not readily recognized or applied by FTs and using a mosaic plot allowed consideration of geometric area to determine (in)dependence.
- Both measurement and natural variation can be recognized through a task aimed at a conceptual understanding of π.
- Distribution can be recognized through a hands on activity that allows viewing an individual observation in relation to others.
- Measurement always includes some sort of variability and witnessing the gross result as product of measurements and conversions can aid in recognizing potential sources of variability.

Further Considerations

- How can these activities be modified or extended to increase FTs understanding of geometry and statistics and how to best teach these topics.
- What are other ways that geometry and statistics can be best presented in an integrated fashion to middle grades students?
- How do these tasks work with middle grade students ?

References

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